

The role of peat decomposition in patterned mires: a case study from the central Swiss Alps

Význam dekompozice rašeliny na povrchově strukturovaných rašeliníštích: případová studie ze švýcarských Alp

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Dedicated to Kamil Rybníček and Eliška Rybníčková on the occasion of their 80th birthdays

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A number of hydrological, botanical, macro- and micro-climatological processes are involved in the formation of patterned peatlands. La Grande Tsa at 2336 m a.s.l. is probably the highest bog in the central Swiss Alps and is unique in its pattern. In two of five pools there is in the contact zone between the basal peat and the overlying gyttja an unconformity in the depth-age models based on radiocarbon dates. Palynostratigraphies of cores from a ridge and a pool confirm the occurrence of an unconformity in the contact zone. We conclude that deepening of the pools results from decomposition of peat. The fact that the dated unconformities in the two pools and the unconformity in the ridge-core all fall within the Bronze Age suggest they were caused by events external to the bog. We hypothesize that early transhumance resulted in anthropogenic lowering of the timberline, which resulted in a reduction in the leaf-area index and evapotranspiration, and in higher water levels and thus pool formation.

Key words: deepening of pools, mires, patterned peatlands, peat decomposition, pool formation

Introduction

Peatlands occur where drainage is impeded and where plant growth is vigorous enough for accumulation to exceed decomposition. There may be hummocks on the surface of peatlands, which are the result of a local presence of trees or shrubs that provide woody biomass that decomposes less readily than graminoids and mosses. Between the hummocks are low spots in which water can accumulate and inhibit growth of vascular plants. The patterns formed by hummocks and hollows may become linear if a gentle slope exists, and the long axes of the hollows are invariably parallel to the contours of the slope. The intricate, winding pattern of pools in string fens (aapamoors) of boreal Finland is an extreme example, but the domal form of raised bogs provides a sufficient slope for the development of an arcuate pattern of pools (e.g. Kermi bogs of Fennoscandia; Cajander

1913, Sjörs 1961, 1983, Eurola 1962, Tolonen 1967, Ruuhijärvi 1983). Both types can be either concentric on flat ground or eccentric on slopes.

Any distinctive pattern in the landscape begs for an explanation. Research on the pools on patterned peatlands has a long tradition and various hydrological and/or biological mechanisms have been proposed. A historic perspective as far back as the 17th century is offered by Gorham (1953) and more recently by Tallis (1983), Sjörs (1998) and Glaser (1998). Eppinga et al. (2010) present data and models on a larger spatial scale for a hypothesis that there is a gradient in the availability of nutrients along a climatic gradient from Scotland to Siberia.

On bogs we may distinguish between the more or less shallow “hollows”, which can be filled with peat of *Sphagnum cuspidatum* and may seasonally dry out, and “pools”, which have open water all year round. Hollows in Estonia have been stable for over 3000 years (Karofeld (1998a). Pools described by Moore (1977), which have been stable for at least 5000 years, were partly filled with various forms of peat and gyttja, not by cyclic replacement but by expansion and contraction of the pools. A mechanism for the transition from hollow to pool involving hydrological changes and differential peat growth is presented by Belyea & Clymo (1998). Studies on the fens of southeastern Labrador and the raised bog of Hammarmossen in central Sweden (Foster et al. 1983, 1988, Foster & Wright 1990) led to the following scenario: (i) When enough peat accumulates on a gently sloping substrate for the formation of irregularities on the surface, perhaps localized around trees or shrubs, water collects in the low lying areas during snow-melt to form small pools. (ii) When a pool fills to the low spot on the down-slope rim, it will drain into the next-lower pool. But when the lowest part of the rim is on a contour, it will drain laterally, producing a long linear pool parallel to the contour. (iii) Plant growth in the pool is inhibited, whereas on the relatively dry adjacent ridges shrubs and even trees increase the height of the ridge and the pool becomes deeper. (iv) Dissolved oxygen in the water has two sources: it gets stirred into the water from the atmosphere by wind and is enhanced by the products of algal photosynthesis. Increased oxygen in the bottom water results in decomposition of the peat on the floor of the pool and the adjacent ridge may be locally undermined. The pool thus becomes deeper and wider. Masses of decomposed peat may rise to the surface as a result of the accumulated methane and carbon dioxide. (v) With a larger water surface and deeper water, algal growth results in accumulation of detrital gyttja, thus burying the decomposed peat. Algal growth (and gyttja formation) may thus pull the system in opposite directions: the additional oxygen may enhance peat decomposition, but by sealing off the peat the gyttja may protect the peat from oxidation. The depth of the pools may have an additional effect: as long as the pools are not very deep they do not contain a thermocline and therefore atmospheric oxygen may reach the bottom of the pool. With increase in depth a thermocline may be established and less oxygen will reach the bottom. (vi) The pool may ultimately fill up with gyttja, the surface of which then can support the growth of mosses and sedges.

In the oriented pools investigated on a fen in south-eastern Labrador, the sequence terminated with step (iv), and the peat on the floor of the pool was completely removed to the mineral substratum, with only pieces of refractory wood remaining (Foster et al. 1983). The arcuate pools on the flanks of the symmetrical raised bog Hammarmossen in central Sweden are well developed and the entire sequence is represented. Radiocarbon dating of the basal peat showed that the bog there grew from the center outwards (Foster & Wright

1990). The early stages of development from hollows to linear pools can be witnessed near the modern bog margin, and the full sequence is present in the older and deeper pools toward the center. In the latter area paired radiocarbon dates from the top of the decomposed peat and the base of the overlying gyttja at four different sites indicate hiatuses of between 430 and 1430 years, which represent the amount of peat removed by decomposition before burial by gyttja (Foster & Wright 1990).

In the present study we test the above hypothesis using the miniature bog of La Grande Tsa in the Swiss Alps (2336 m a.s.l.), which has five parallel linear pools with orientation (Figs 1 and 2) that may fit the model so well represented in boreal forests. Patterned mires are rare in the Alps. Ullmann & Stehlik (1972) provide an early description of the raised bog Rotmoos near Weichselboden at a lower altitude (700 m a.s.l.) in the calcareous eastern Alps of Upper Styria (Austria), which has a special local climate in a deep valley, where the sun never reaches the bog during winter. At this site there are eccentric arcuate hollows comparable to those at Hammarmossen in central Sweden (Foster & Wright 1990) but no pools as at La Grande Tsa. Usually hollows only contain water during high-water periods (e.g. after snow melt), whereas pools are full of water throughout the year (Belyea & Clymo 1998). On a bog both hollows and pools can coexist, as at Hammarmossen and Nittenmossen (Foster & Wright 1990).

Of the many questions there are about the formation of pools on bogs (Sjörs 1961, 1983, 1998, Boatman & Tomlinson 1973, 1977, Boatman 1977, Glaser 1998, Karofeld 1998a, b) we concentrate on the mechanisms responsible for the deepening of already existing pools.

Materials and methods

The site La Grande Tsa

The plateau of La Grande Tsa (46°09'18.74"N, 7°21'52.20"E, 2336 m a.s.l.) is situated in the Val d'Hérémence, a southern tributary valley of the Rhône Valley in the central Swiss Alps, about 8 km south of the city of Sion (French, in German Sitten, Fig. 1). Two palynological sites near La Grande Tsa are Mont Carré (Welten 1982) and Gouillé Rion (Tinner et al. 1996, Tinner & Kaltenrieder 2005). In addition, macrofossils including charcoal were analysed contiguously at Gouillé Rion, and upland soil surveys were used for biosequence reconstructions (Tinner et al. 1996, Tinner & Kaltenrieder 2005). The bedrock consists mainly of schists belonging to the Penninic nappe of the Grand-St-Bernard.

There is no local weather station but the annual mean temperature can be estimated to be about 1 °C and the annual precipitation to at least 1100 mm. For the nearby hydroelectric power station Grande Dixence annual means of 1.4 °C and 920 mm are cited (Roh & Rey 1989). The climate is subcontinental.

Roh & Rey (1989) provide a phytosociological description of the vegetation in the area and a map of the bog, which we use in a simplified form (Fig. 2). La Grande Tsa is mentioned as the highest well-developed bog in the Swiss Alps; its patterning is unique for this country and probably the entire Alps (in German: Terrassenhochmoor). In addition, the bog and its surroundings harbour several plant species that are rare in the Central Alps (i.e. *Carex limosa*, *C. paupercula*, *Sedum villosum*). For this reason the site is now a nature reserve and fenced. The history of the vegetation during the Holocene is known for two



Fig. 1. – (A) Google map of the Alpine arch showing the location of Sitten/Sion in the upper Rhône Valley (Valais). (B) Google map showing the Val d'Héremence joining the Rhône valley near Sion, and the three neighbouring sites sampled. (C) The three neighbouring sites: Goullé Rion is a lake at 2343 m a.s.l. (Tinner et al. 1996, Tinner and Kaltenrieder 2005); La Grande Tsa is a patterned peatland with distinct pools at 2336 m a.s.l. (this paper) and Mont Carré is a mire without patterns at 2290 m a.s.l. (Welten 1982).

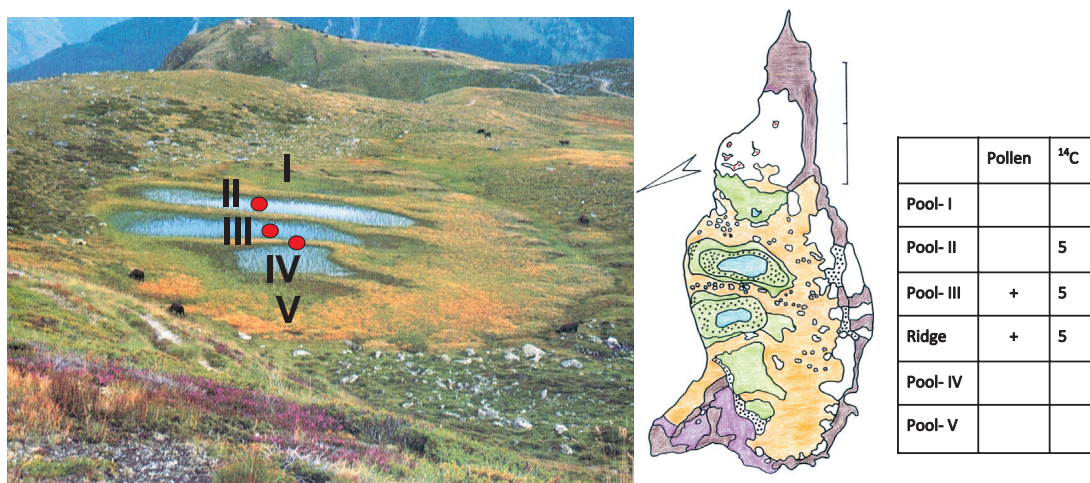


Fig. 2. – (A) Overview of the study bog. The photograph shows the pools numbered from bottom to top, the coring sites are marked with red dots. (B) A simplified map of the vegetation (redrawn from Roh and Rey 1989) on which the colours indicate: blue – open water (different in 1989 and 2004); orange – *Trichophoretum caespitosi alpinum*; green – *Caricetum limosae*; white – *Sphagnetum fuscae*; brown – *Caricetum fuscae*; violet – *Caricetum fuscae trichophoretosum*; black dots – *Caricetum rostratae*; small red dots – open peat. (C) the three coring sites with radiocarbon dating and two with pollen diagrams (ridge and pool).

nearby sites: (i) The palynological sequence for Mont Carré (2299 m a.s.l., Welten 1982) covers the period from the Younger Dryas to the onset of the Roman period but the rate of accumulation and sampling resolution are low for the period relevant to La Grande Tsa. (ii) The pollen and macrofossil records from Gouillé Rion (2343 m a.s.l., Tinner et al. 1996) cover the period from the Bølling to the present and were used to reconstruct the long-term timberline dynamics. Today all three sites are above the timberline but below the tree line (~2350 m a.s.l. in the 1990s, today ~2400 m a.s.l.). Plant macrofossils show that the site was forested already 200 years after the onset of the Holocene. *Larix decidua* and *Betula pendula* forests remained open (with e.g. heliophilous *Juniperus nana* and *Dryas octopetala*) till ~9500 cal. yr BP. Between 9500 and 3600 cal. yr BP dense forests of *Larix decidua*, *Betula pendula* and *Pinus cembra* occurred around these sites (Tinner et al. 1996, Kaltenrieder et al. 2005, Tinner & Kaltenrieder 2005). These forests were damaged by man during the Bronze Age, mostly by the use of fire to gain summer pastures (Colombaroli et al. 2010). Dynamic vegetation models (FORCLIM) show that the location of these sites was highly sensitive to climate-induced oscillations in the timberline as recorded in the pollen and macrofossil records (Heiri et al. 2006). Dynamic landscape simulations (LANDCLIM) suggest a paramount long-term role of soils in determining the composition and dynamics of the vegetation around the three sites (Henne et al. 2011).

Methods of coring, sampling, dating and pollen analysis

Cores were obtained from two pools and an intervening peat ridge in the patterned mire of La Grande Tsa (Figs 2 and 3). In 1991 we cored the ridges between pools I and II and between pools III and IV, using a Russian peat corer. The latter core, taken in

Trichophorum alpinum stands, was nearly complete and was therefore chosen as the master core for dating and pollen analysis (now labelled ridge-core). In 1993 we re-cored pools I, II (not analysed) and III using a square-rod piston sampler (Wright 1967). In 2004 we revisited pool II with a square-rod piston sampler for dating the unconformity.

Lithostratigraphy

The sediments in the cores were described and categorized based on visual features following Troels-Smith (1955).

Radiocarbon dating

The goal of radiocarbon dating (Table 1, Fig. 4) was to test the hypothesis formulated for Hammarmossen in Sweden (Foster et al. 1988, Foster & Wright 1990) that the pools deepen as result of decomposition of peat. Therefore, the distances between each of the ^{14}C samples were smallest in the contact zone between peat (below) and gyttja (above). We submitted bulk samples of peat and of gyttja for AMS measurement at the radiocarbon laboratory in Poznań (see Table 1). For the depth-age models we used the median ^{14}C calibrated values based on Calib version 6.0 (Reimer et al. 2009), with linearly interpolated values between our ^{14}C calibrated ages (Fig. 4).

Table 1. – The radiocarbon dates of bulk samples of gyttja and peat collected from the ridge and pools II and III at La Grande Tsa (2336 m a.s.l.), which were measured at the Poznań Radiocarbon Laboratory, Poland. F stands for fine detritus and C for coarse detritus.

Core	Litho-stratigraphy	Depth in cm	Laboratory number	Radiocarbon age BP	Calib6.0: cal. yr BP	Range (2σ)
Ridge	peat	10	Poz-8617	1720±30 BP	1629	1704–1554
	peat	65	Poz-8791	3305±35 BP	3529	3629–3452
	peat	105	Poz-8787	3115±35 BP	3345	3439–3247
	gyttja F	265	Poz-8788	6160±50 BP	7065	7234–6906
	gyttja C	280	Poz-8789	6360±50 BP	7298	7419–7174
Pool III	gyttja	14	Poz-2107	2515±35 BP	2590	2741–2471
	gyttja	18	Poz-2108	3080±40 BP	3301	3383–3171
	peat	20	Poz-2110	3720±40 BP	4062	4225–3929
	peat	24	Poz-2111	3915±40 BP	4349	4510–4235
	peat	50	Poz-2112	4680±50 BP	5410	5580–5311
Pool II	gyttja	10	Poz-8782	1105±30 BP	1009	1065–937
	gyttja	30	Poz-8616	2350±35 BP	2361	2651–2316
	gyttja	45	Poz-8783	3120±35 BP	3350	3441–3254
	peat	47	Poz-8784	3010±35 BP	3218	3334–3078
	peat	54	Poz-8785	4380±40 BP	4943	5211–4852

Palynology

Pollen and spore analyses were performed on the ridge-core and pool III core (Figs 5–7) to provide further evidence of the unconformity at the transition from peat to upper gyttja as indicated by the radiocarbon ages. All samples were prepared by the acetolysis method

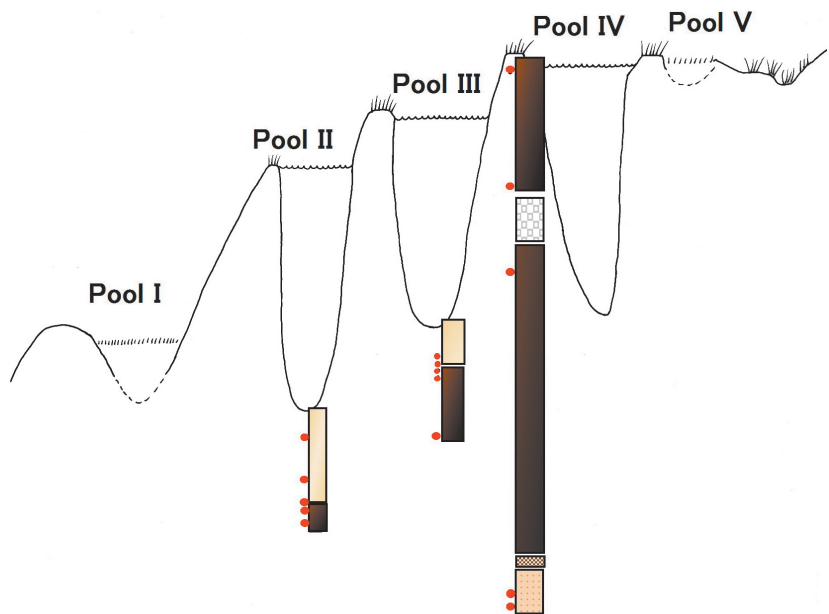


Fig. 3. – Cross-section through the five pools, four ridges and their lithostratigraphy. Dark brown indicates peat, light beige gyttja and red dots the location of the radiocarbon dated samples. In 2004 pools I and V were overgrown. The vertical scale is 25 times greater than the horizontal scale.

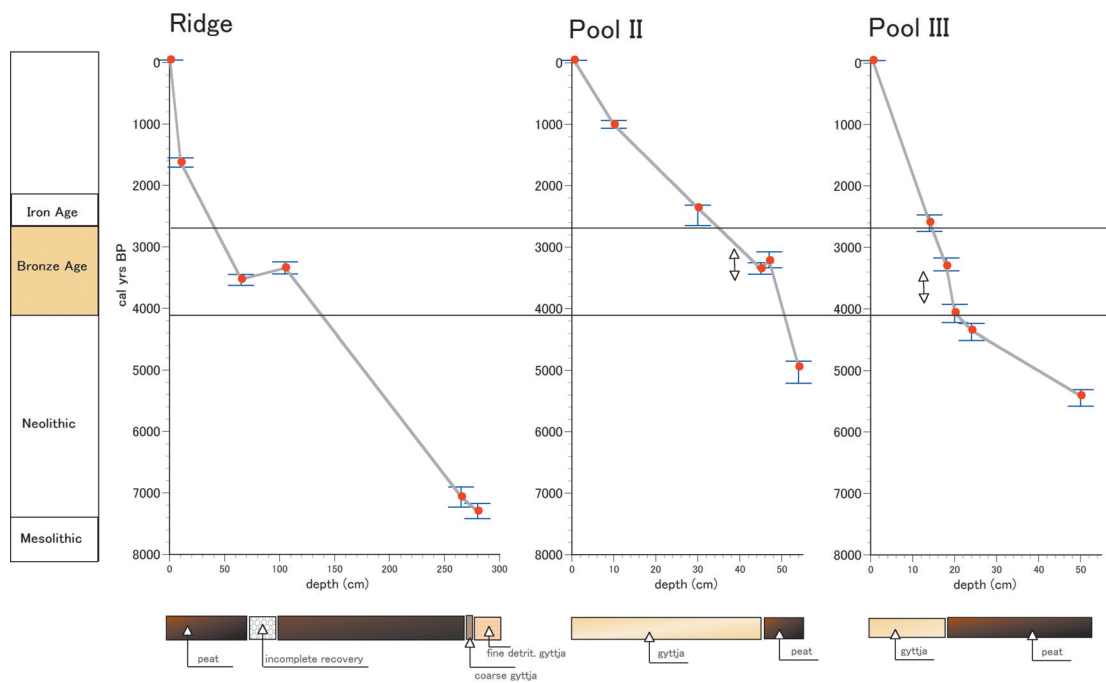


Fig. 4. – The depth-age models for the ridge-core and pools II and III presented on a common time scale. For radiocarbon dates see Table 1.

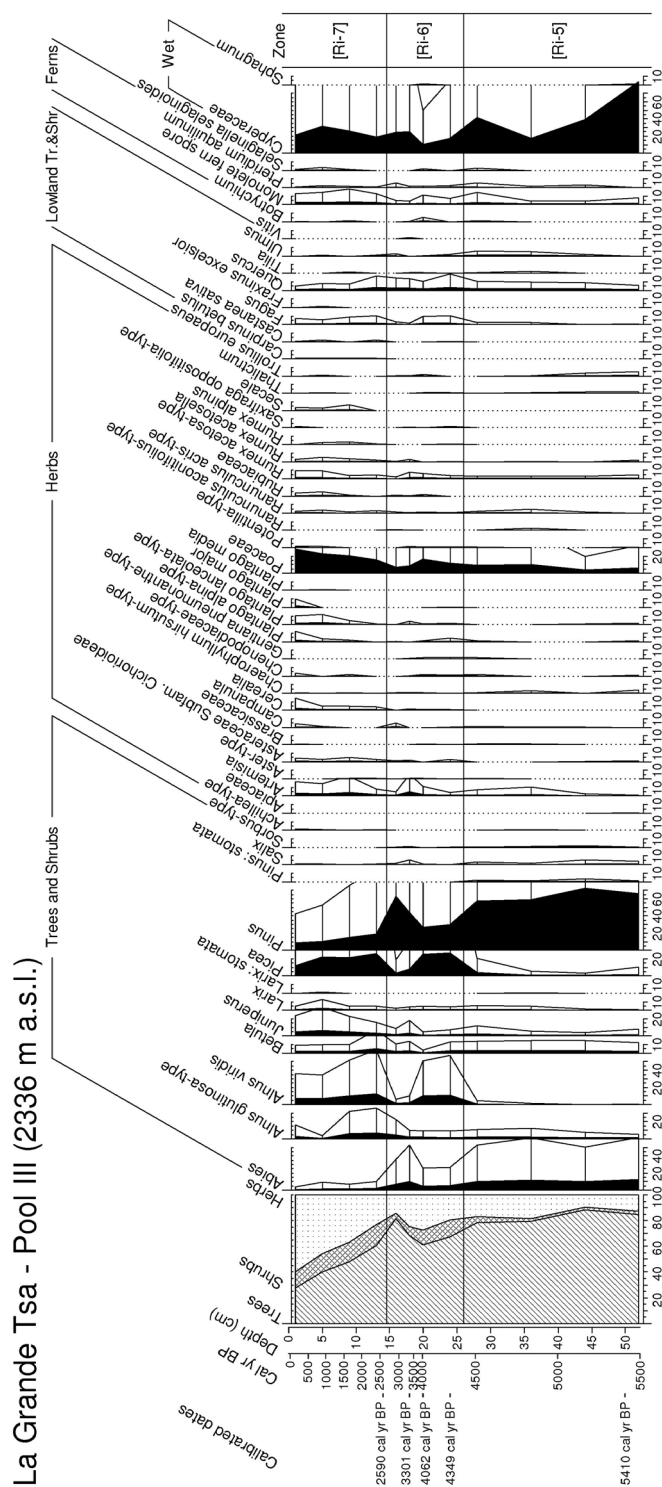
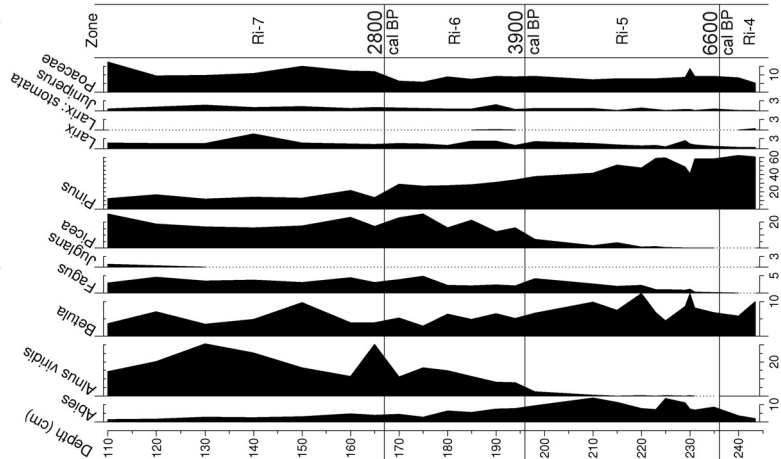
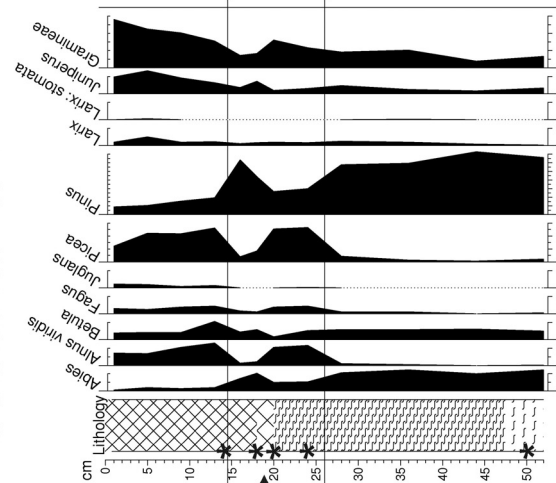


Fig. 6. – Pollen diagram for pool III (selected taxa only, depth-linear)

Goullé Rion (Tinner et al. 1996)



La Grande Tsa: Pool III



La Grande Tsa: Ridge

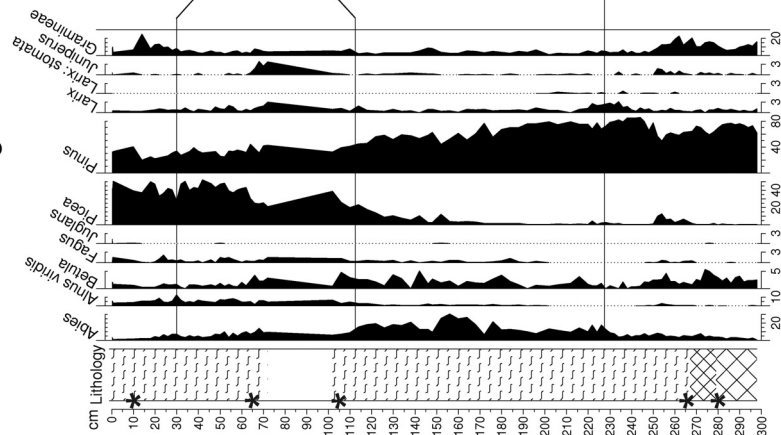


Fig. 7. – Comparison of pollen stratigraphy recorded for the ridge and pool III, based only on the most relevant taxa and the standard diagram for the area, Goullé Rion (Tinner et al. 1996). The asterisks indicate the position of the radiocarbon dated samples. The depth scale of the pool diagram is greatly expanded.

(Faegri & Iversen 1989). Pollen percentages are based on the pollen sum (100%) of AP (arboreal pollen, including trees and shrubs) and NAP (non-arboreal pollen). Spores of *Bryophyta* and *Pteridophyta* and pollen grains of *Cyperaceae* and aquatic plants are excluded from the pollen sum. At least 500 terrestrial pollen grains were identified to the lowest possible taxonomic level using the keys of Punt (1976), Punt & Clarke (1980, 1981, 1984), Punt et al. (1988, 1995, 2003), Punt & Blackmore (1991), Moore et al. (1991) and Beug (2004). For calculating the percentages and printing the results, Tilia and TGView 1.5.11 programs (Grimm 2004) were used. Pollen-zone boundaries shown by continuous lines are based on a comparison with the regional pollen zones recorded at Gouillé Rion (Tinner et al. 1996).

Results

Lithostratigraphy

The ridge core contains gyttja at the base of the core, showing that the depression in which the peat developed was originally a lake. This basal gyttja was not reached in the pool cores. The pool cores consist of peat below and a second (younger) layer of gyttja above (see Figs 3, 5–7).

Radiocarbon dates and depth-age models

After calibration of the radiocarbon dates (Table 1) we developed three depth-age models (Fig. 4). The neutral term “unconformity” includes both hiatuses and a discontinuity.

Palynostratigraphy

The pollen records in the ridge-core, the pool III core and their combination (Figs 5–7) can be used to reconstruct the dynamics of the patterned mire on the basis of individual biostratigraphies. In addition, the record in the ridge core can be compared with that reported for the nearby lake of Gouillé Rion by Tinner et al. (1996). For comparison we added the local pollen-assemblage zones of this regional standard to the pollen diagrams of La Grande Tsa (Ri-4 to Ri-7). The ridge-core starts around 7300 cal. yr BP, i.e. during the second half of the Atlantic period or zone Ri-4 of Gouillé Rion. *Larix* was locally present (stomata only found at Gouillé Rion, but abundant macrofossils) as well as *Pinus cembra* (stomata of *Pinus* sp. at both sites, abundant macrofossils at Gouillé Rion). Among the pollen *Abies* is relatively important, but occasional needle finds (Tinner et al. 1996, Kaltenrieder et al. 2005) indicate that the local presence of *Abies* at these high altitudes was rather rare. In both diagrams the first slight increases in *Picea* and *Alnus viridis* occur in zone Ri-5. In zone Ri-6 there is a distinct increase in these two taxa and *Juniperus* (*J. nana* in the macrofossils) and a decline in *Abies*. This decline in *Abies* is also recorded in the uppermost samples from the site at Mont Carré (Welten 1982).

The first appearance of the grazing indicator *Plantago alpina* in zone Ri-5 most probably documents the onset of alpine summer farming in the Gouillé Rion area, which occurred at latest during the Bronze Age (Tinner et al. 1996, Kaltenrieder et al. 2005).

Pollen grains of *Cerealia*-type and *Vitis* were certainly blown up from the valley. This is in accordance with the pre-Roman records of *Vitis* (since the 8th century BC) in archaeological,

archaeobotanical and palynological from the main valley of the Valais (Curdy et al. 2009). It is in this pollen zone Ri-6 (~3900 to 2800 cal. yr BP) that the unconformities occur in all three depth-age models (Fig. 4). Zone Ri-6 corresponds largely to the Bronze Age (4200–2800 cal. yr BP), when the forest around the patterned mire was destroyed by fires of human origin (Colombaroli et al. 2010). The transition from zones Ri-6 to Ri-7 coincides approximately with the transition from the Late Bronze Age to Early Iron Age (i.e. 800 BC). During zone Ri-7 (ca 2800–1625 cal. yr BP) *Cerealia*-type pollen forms a nearly continuous curve and the first grains of *Juglans* occur (indicating the Roman occupation of the Valais).

The core from pool III indicates that the hiatus in the peat record occurs in zone Ri-6, i.e. after the decrease in *Abies* and *Pinus* and increase in *Alnus viridis* and *Picea*.

Discussion

In both pools there is an unconformity in the radiocarbon dates for below and above the contact between the peat (upper) and gyttja in the depth-age models, indicating a slight reversal in pool II and distinct slow-down (below 0.3 mm yr^{-1}) in the estimated rate of accumulation in pool III (Fig. 4). The unconformity in pool III is somewhat older than that in pool II. This is in accordance with the situation at Hammarmossen, where the oldest and longest gaps in the depth-age models are near the top of the domed bog, although the difference in age at La Grande Tsa is small and we have paired peat-gyttja ages for only two pools, compared to eight pools at Hammarmossen (Foster & Wright (1990)). Nevertheless, we infer that at La Grande Tsa the pools also deepened because of peat decomposition, as indicated by the unconformities in the depth-age models (Fig. 4).

At least another three questions remain unanswered: (i) If the algae take up old carbon from the decomposing peat, may we get radiocarbon ages for the gyttja just above the peat that are too old? If so, the age of the upper sample in the pair of dates (measured on bulk gyttja) would be too old, and therefore the hiatus may be even longer than indicated by the dates. (ii) The unconformity in radiocarbon dates in the ridge-core brackets the gap in the core that we consider to be a coring artifact, namely incomplete recovery. But could it be that this has a common cause with the unconformities in the pool cores? (iii) This leads to the main question: is the peat decomposition caused by local autogenous processes in the bog or by allochthonous processes such as climate, fire, or land use? Or is it a combination of both? In questions (ii) and (iii) the hydrology of the mire plays a central role. Currently we have no hydrological measurements for La Grande Tsa, for which it would be interesting to know the seasonal difference in hydrology between periods of snow melt and mid-summer.

Foster & Wright (1990) discuss three models of pool formation. According to the neutral model, pools are initiated when the bog begins to form and therefore extend from the surface down to the minerogenic soil. This model obviously does not apply to La Grande Tsa. According to the autogenic model, pool formation is controlled by the local bog morphology and hydrology, with progressively younger pools from the centre of the dome towards the margin, as is well illustrated by the situation at Hammarmossen (Foster & Wright 1990). According to the allogenic model, however, pool formation occurs simultaneously across the bog in response to an external cause such as a climatic change (e.g. Bolton Fell Moss; Barber 1981).

At La Grande Tsa the unconformity at the transition from peat to gyttja is older and longer in pool III (4062 to 3301 cal. yr BP) than in pool II (3218 to 3350 cal. yr BP), a fact that accords with the autogenic model. But if the unconformity in the ridge-core (3345 to 3529 cal. yr BP) is not a coring artifact, a certain similarity to that recorded in pool II becomes obvious. As shown in Fig. 4 the three unconformities all occurred during the Bronze Age. This period is considered to be (among others) characterized by a relatively warm climate and the first (or second) period of the use of pastures above the timberline, i.e. an early transhumance (Gobet et al. 2003, Tinner et al. 2003, Röpke et al. 2011). Summer temperatures in the Bronze Age were already lower than during the Holocene optimum but warmer than during the cool phase at the onset of the Iron Age (e.g. van Geel & Renssen 1998, Heiri et al. 2004, Holzhauser et al. 2005, Wanner et al. 2011). Local summer farms resulted in an anthropogenic lowering of the timberline, as indicated by the decrease in macrofossils of *Larix decidua* and *Pinus cembra* at Gouillé Rion (Tinner et al. 1996). When the abundances of these two subalpine tree species were reduced (*L. decidua*) or completely eradicated (*P. cembra*), the leaf area index (LAI) per unit of ground surface decreased and therefore the evapotranspiration would have decreased. This meant that more water remained in the soil and the mire. Examples of high humidity caused by anthropogenic deforestation (for younger periods and with often quite different effects such as increases or decreases in pH) are also provided by Speranza et al. (2000), Lamentowicz et al. (2007) and Hájková et al. (2012).

We thus hypothesize that La Grande Tsa is an example of the allogenic model, in which external processes (i.e. anthropogenic lowering of the timberline) changed the hydrology and led to a deepening of the pools. Such a scenario resembles, to some degree, the one described for the origin of blanket mires, although the result is very different (Moore 1973, 1975). Belyea & Clymo (1998) propose a mechanism for how an increasing water level (both seasonally low and high water levels) can lead to the transformation of a hollow into a pool. They state: “Continued lateral expansion of the hummocks retards water flow and the water level rises (...), so that the hollow centre is submerged throughout the year. The failed hollow has become a pool: a fate from which there is little prospect of recovery”. In good agreement with our interpretation, increasing surface wetness initiated the formation of patterns also in quite different mire systems, e.g. in Scottish fens (Charman 1995). Moreover, the paired radiocarbon dates for samples from just below and above the transition from peat to gyttja at La Grande Tsa confirm the conclusions drawn from the study of Hammarmossen (Foster & Wright 1990) that pools can deepen by peat decomposition.

As already shown by Rybníček & Rybníčková (1987), hiatuses in mid-Holocene mires can have a number of causes and further research with greater temporal and spatial resolution is needed to resolve this problem.

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Souhrn

Na utváření povrchové struktury rašelinišť, sestávající z bultů, šlenků a jezírek, se podílí celá řada hydrologických, vegetačních, mikroklimatických a makroklimatických procesů. Objektům této stratigrafické a palynologické studie bylo malé rašeliniště La Grande Tsa, které je možná nejvýše položeným rašeliništěm v centrální části švýcarských Alp a má z hlediska Alp unikátní povrchovou strukturu, tvořenou pěti paralelními protáhlými jezírky. Pomocí vrtáků byly odebrány profily ze dvou jezírek a z protáhlého bultu mezi nimi. Profil z bultu obsahoval na bázi jezerní sediment gyttju. To naznačuje, že deprese, v níž se rašeliniště vyvinulo, byla původně jezerem. Gytja však nebyla nalezena na bázi profilů odebraných z jezírek. V profilech z jezírek byla báze tvořena rašelinou, na níž nasedala gyttja. V obou profilech z jezírek byl zjištěn nesoulad mezi radiokarbonovým datováním svrchních vrstev rašeliny, tvořící bázi profilu, a radiokarbonovým datováním spodních vrstev navazujících gyttji. V jednom případě ukazoval model závislosti stáří sedimentu na hloubce profilu výrazné zpomalení sedimentace na kontaktu mezi rašelinou a gyttjou, v druhém dokonce vycházelo dno jezírka o něco starší než pod ním uložená rašelina. Podobný nesoulad ukázal i profil z vyvýšeného bultu. Zjištěné výsledky odrážejí proces prohlubování jezírek z důvodu dekompozice podloží rašeliny. Rovněž dokládají, že podle zjištěného stáří a podle pylového záznamu odpovídá nesoulad v datování, ať už byl způsoben hiátem nebo pouhou diskontinuitou, době bronzové, a to ve všech třech analyzovaných profilech. Ve studovaném území je toto období charakterizováno dosti teplým klimatem a buď první nebo druhou doloženou transhumancí (přesunem zvířat a pastevců přes vysoké polohy Alp), která vedla ke snížení hranice lesa. Menší listová plocha vegetace pak vedla k menší evapotranspiraci a tedy ke zvýšení hladiny vody na rašeliništi, jehož hydrologické poměry byly zřejmě ovlivňovány širším okolím. Vznik jezírek tedy patrně podmiňují procesy probíhající v okolí rašeliniště, nikoli na rašeliništi samotném.

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